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Original Article

Continuous positive airway pressure and noninvasive ventilation adherence in children

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ABSTRACT

Background: Adherence to continuous positive airway pressure (CPAP) and noninvasive ventilation (NIV) is crucial for the successful treatment of sleep-disordered breathing. The aim of our study was to analyze the adherence of children to long-term home CPAP/NIV treatment.
Methods: We analyzed data from all consecutive patients older than the age of 2 years, in whom CPAP/NIV treatment was initiated in a specialized pediatric NIV and in those who were receiving CPAP/NIV treatment at home for at least 1 month. Data of the memory cards of the ventilators and nocturnal gas exchange were analyzed during a routine CPAP/NIV overnight control in the hospital. CPAP/NIV adherence during the previous month was analyzed according to patient's age, ventilatory mode, type of interface, nocturnal gas exchange, and duration of treatment.
Results: The data of 62 children (mean age, 10 ± 5 years) with obstructive sleep apnea ($n = 51$) treated with CPAP and neuromuscular disease ($n = 6$) or lung diseases ($n = 5$) treated with NIV were analyzed. Mean adherence was 8:17 ± 2:30 h:min per night, and the results did not significantly differ between CPAP and NIV adherence. Seventy-two percent of the patients used their device >8 h per night. The mean number of nights of CPAP/NIV use during the last month was 26 ± 5 nights per month. Treatment adherence was not correlated to age, the type of underlying disease, the type of interface (nasal, facial mask, or nasal cannula), nocturnal gas exchange, and duration of CPAP/NIV treatment.
Conclusion: Long-term CPAP/NIV adherence at home was extremely high in this group of children followed in a pediatric NIV unit. This finding may explain the lack of effect of the interface, nocturnal gas exchange, and duration of CPAP/NIV treatment.

1. Introduction

Noninvasive continuous positive airway pressure (CPAP) and noninvasive ventilation (NIV) are effective treatments for obstructive sleep apnea (OSA) and nocturnal hypoventilation, respectively. By maintaining a constant positive pressure in the airways during the whole breathing cycle, CPAP is able to correct the complete (apnea) or partial (hypopnea) closure of the upper airways during sleep. By delivering a positive pressure or a volume during the patient's inspiration, NIV is able to reverse nocturnal alveolar hypoventilation in patients who experience hypoventilation during sleep, such as patients with restrictive or neuromuscular disease or patients with lung disease. Adherence to these treatments is essential for their efficacy. Indeed, a study performed in 52 children with OSA showed a correlation between CPAP use and the improvement in daytime sleepiness assessed by the change in the Epworth Sleepiness Scale [1]. Moreover, regular overnight use of NIV treatment has been shown to correct nocturnal and daytime gas exchange in children with neuromuscular disease [2,3]. However, the minimal hours of CPAP or NIV use for an optimal effectiveness in children is not known and may vary by the age

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of the patient and by the type and the severity of the underlying disease.

Adherence has to be assessed on objective data. Indeed, initial studies reported adherence to be high when using self-reported or parent-reported measures of CPAP use [4,5]. However, adherence proved to be lower when objective adherence was gathered from the ventilators [6]. Nowadays, objective adherence is accessible from most of the ventilators not only as an hour meter recording (i.e., when the ventilator is switched on), but also from built-in software that delivers a detailed report of all the parameters of the ventilator, such as airway pressure, leaks, and several respiratory parameters, thus allowing a more comprehensive approach of observing the patient's sleep with CPAP or NIV treatment [7,8].

Numerous factors, such as age [9,10], type of interface [9], and the association of an educational program may influence treatment adherence [11]. With the rapid increase of children needing CPAP or NIV treatment [12], together with continuous improvements in ventilators and interfaces, adherence may change in children. The primary objective of our study was to assess the objective compliance in children treated with long-term CPAP or NIV treatment at home with a standardized medical follow-up in a tertiary pediatric NIV unit. The secondary objective was to determine the variables significantly associated with CPAP/NIV adherence.

2. Methods

2.1. Subjects

Between June 2012 and January 2013, data from all consecutive patients older than the age of 2 years, who were receiving CPAP or NIV treatment at home for at least 1 month and who were hospitalized for a routine CPAP/NIV overnight control in the hospital, were analyzed. Nocturnal gas exchange with CPAP/NIV was recorded in all the patients. Demographic data and ventilator and interface equipment were obtained. Patients were classified in three groups according to the underlying disease: OSA, restrictive or neuromuscular disease, or lung disease.

2.2. CPAP/NIV initiation procedure

CPAP or NIV treatment was started for all patients with the child's parents in our specific pediatric NIV inpatient unit with well-trained and experienced staff. The patient was discharged home when he or she was able to sleep at least 6 h with CPAP or NIV treatment during the night and when he or she presented normal nocturnal gas exchange with the ventilator. A home visit was performed by the home care provider on the day of discharge, after one week, and then every 1–3 months, as well as at any time when necessary. The parents were instructed to contact the NIV unit in case of any problem with the interface or the ventilator. A systematic sleep study with CPAP or NIV treatment and recording of overnight pulse oximetry (SpO_2) and transcutaneous carbon dioxide ($PtcCO_2$) was performed in the hospital 1 month after the start of treatment and then every 2–6 months according to the age and the pathology of the child [13]. Patient adherence was assessed during this systematic hospital visit.

The study was approved by the Institutional Review Board of the French Learned Society for Respiratory Medicine "Societé de Pneumologie de Langue Française."

2.3. Ventilator equipment

Among the ventilators used for home CPAP/NIV treatment in our pediatric unit, the following were equipped with built-in software allowing the ability to download the report on a PC: VPAP IV and S9 (ResMed TM; North Ryde, N.S.W., Australia, with ResScan TM software), Trilogy 100 (Philips Respironics™; Murrysville, Pa., USA, with Direct View™ software), and ICON (Fisher & Paykel TM; Auckland, New Zealand with InfoSmart™ software). Thus only data from patients ventilated with these devices were analyzed.

Patients with OSA were treated with CPAP or bilevel positive airway pressure (BPAP) treatment, whereas patients with neuromuscular or lung disease were treated with NIV with a hybrid mode that combined a pressure mode with a target volume mode (average volume-assured pressure support) [14,15].

For every patient, great care was taken to select the most appropriate interface with regard to the patient's underlying disease and ventilatory mode [16]. Nasal masks were preferred over facial masks, which were only used in case of important mouth leaks or the impossibility to close the mouth during sleep. In children older than the age of 8 years, nasal cannula was proposed as first choice in case of CPAP or BPAP ventilation [16]. The interface associated with the best tolerance and comfort was selected and was defined by the absence of any skin injury, pain, discomfort, or leaks. In case of intolerance of the interface after the initial discharge [16,17], other interfaces were tried and the most appropriate and comfortable interface was selected by trained nurses with systematic medical supervision.

2.4. Evaluation of patient adherence

Patient adherence was downloaded from the built-in software of the ventilator during the routine hospital visits. Data from patients with variable durations of home CPAP/NIV treatment thus were analyzed. The mean daily adherence (excluding nonuse nights), the mean number of nights used, and the number of nights the patient used the ventilator for more than 8 h or less than 3 h during the last month were analyzed. When available, the unintentional leaks also were analyzed. The duration of home CPAP/NIV use also was reported.

2.5. Statistical analysis

Data are expressed as mean ± standard deviation. The comparison of treatment adherence according to the underlying diseases and the adjustment for confounders such as the type of masks (facial, nasal, and nasal cannula) were performed using analysis of variance in case of normal distribution or the Kruskal–Wallis analysis of variance on ranks was otherwise used. The comparison of adherence according to the patients' age (older or younger than the age of 10 years) or duration of treatment was performed using the *t* test in case of normal distribution or the Mann–Whitney rank sum test was otherwise used. To assess a potential link between the CPAP/NIV adherence and the treatment efficacy documented by nocturnal gas exchange parameters, correlations were performed with Pearson product moment correlation coefficients when data were normally distributed or Spearman rank correlations when data were not normally distributed. A P value <.05 was considered as significant.

3. Results

The data of 62 patients (ages, 2–18 years) were analyzed (Table 1). The majority of the patients had OSA (82%). Most patients (61%) were ventilated with a nasal mask; these patients were significantly younger than the patients ventilated with a facial mask or nasal cannula ($P < .001$).

Mean objective adherence was extremely high with a mean use of 8:17 ± 2:30 h:min per night and 72% of the patients using their CPAP or NIV >8 h:min per night (Table 1). The mean number of

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